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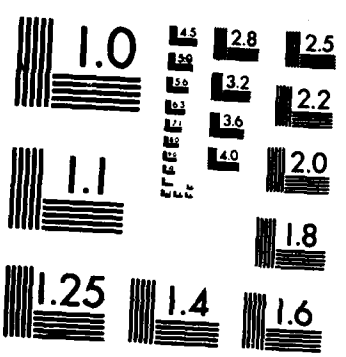

THE INFLUENCE OF SENIORITY ON C^2 EXPERIMENTAL PERFORMANCE

REVISED 27 August 1986

Prepared For:

Contract DCA100-86-C-0004

Headquarters Effectiveness Evaluation
Defense Communications Agency
Washington, D.C. 20305

Defense Systems, Inc.
7903 WESTPARK DRIVE
MCLEAN, VIRGINIA 22102
(703) 883-1000

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This report examines the influence of seniority on performance during a command and control (C^2) effectiveness experiment and is based on data obtained during the third in a series of experiments designed to examine the influence of C^2 organization on system performance.

The experiments are part of a larger program, whose purpose is to define, measure, and identify determinats of C^2 effectiveness. The experimental effort is jointly sponsored by the Defense Communications Agency ~~(DCA)~~ and the U.S. Naval Postgraduate School (NPS), with actual experimental trials being conducted in the NPS C^2 Wargame Analysis and Research Laboratory ~~(WARLAB)~~ using NPS officer-students as experimental subjects.

This set of experiments compared the performance of higher and lower echelons (i.e., Fleet and Carrier Battle Group roles) in the conduct of planning and battle management tasks and also examined the impact of role and specialization on C^2 performance.

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The Influence of Seniority on C^2 Experimental Performance

BACKGROUND

This report examines the influence of seniority on performance during a command and control (C^2) effectiveness experiment and is based on data obtained during the third in a series of experiments designed to examine the influence of C^2 organization on system performance.[1]

The experiments are part of a larger program, whose purpose is to define, measure, and identify determinants of C^2 effectiveness. The experimental effort is jointly sponsored by the Defense Communications Agency (DCA) and the U.S. Naval Postgraduate School (NPS), with actual experimental trials being conducted in the NPS C^2 Wargame Analysis and Research Laboratory (WARLAB) using NPS officer-students as experimental subjects.

This set of experiments compared the performance of higher and lower echelons (i.e., Fleet and Carrier Battle Group roles) in the conduct of planning and battle management tasks and also examined the impact of role and specialization on C^2 performance.

The effects of seniority, addressed by this report, were not part of the analysis plan at the outset of the experiment, and data to support them were sparse. This report therefore represents a search for insights more than an account of statistical findings. It is therefore not limited to the NPS experiments, but includes a short discussion of observations in fleet exercises.

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[1] 1985 C^2 Effectiveness Experiments, 12 May 1986

EXPERIMENTAL DESIGN

The experimental subjects were divided into two groups (A and B) with each group being subdivided into cells representing nodes in the command structure. The experimental command structure consisted of five command nodes: Commander Second Fleet (COMSECONDFLT), three Carrier Battle Groups (CVBGs), and CONTROL/Commander-In-Chief Atlantic Fleet (CINCLANTFLT). Performance measures were taken for all except CONTROL/CINCLANTFLT. Unlike previous experiments, where students played various roles throughout the experimental runs, in this experiment the students played the same roles throughout (i.e., CVBG commander, action officer, communicator, etc.).

The scenario setting is a battle force consisting of three CVBGs operating under a numbered fleet commander in a high threat environment. Experimental trials are conducted in both a clear and a disturbed communications environment. As with previous experiments, these experiments examine the impact of varying organizational structures on the performance of the command nodes and the force as a whole.

The C^2 performance of the experimental cells under varying conditions is scored using measures of performance derived from the Headquarters Effectiveness Assessment Tool (HEAT). The performance measures are tailored to accommodate inherent simulation and laboratory artificialities and collectible data. Tactical battle outcomes, provided by the simulation, are also used to measure group performance.

For each experimental trial, a team is required to comprehend a military problem, devise a solution, and then attempt to implement it despite ORANGE interference. Systematic variation of factors over many such trials produces a rich experimental database. From these data come insights regarding C^2 theory and preliminary estimates of causation within C^2 systems.

SENIORITY VARIATION

Experimental results to date are internally consistent, but the range of applicability remains unexamined. Therefore, one research objective of the most recent experiments was to conduct duplicate trials using personnel with varying seniority, experience, and expertise. Administrative restrictions prevented duplicate trials, but modification and careful analysis of the primary trials has allowed some testing of impacts of personnel variation.

Seniority has been introduced in two ways:

- actual variation in the seniority of the officer assuming the role of the senior BLUE force commander (COMSECONDFLT);
- notional seniority variation defined by the position of the role in the command hierarchy.

The actual variation in COMSECONDFLT saw that role played by a Navy Lieutenant and an Air Force Captain (NPS students); two Navy Captains (NPS faculty members); and a Rear Admiral (from OP 953). The NPS faculty members involved were the director of the tactics department and a senior professor who has published widely on naval command and control. Of the 16 game "days" played by each group, a Navy Captain participated in one day, and the Rear Admiral in a second; 14 days (7 sessions) were played entirely by junior personnel.

Notional variation saw differing command centers comparably staffed but with different authority, responsibility, and discretion.

HYPOTHESIZED IMPACT

The literature on experimentation provides two arguments for improved individual performance when senior personnel are present. First, experience matters. Senior personnel will normally have greater experience and perform laboratory tasks that are realisticly better than less experienced subjects. Second, more junior personnel have higher motivation and stimulation when senior personnel are present. Greater realism is perceived and an opportunity for gaining attention and building reputation (for good or ill) is perceived by junior personnel.

FINDINGS

The basic findings are as follows:

- The effects of seniority were mixed. Real seniority had a weak tendency to decrease C^2 capacity. Notional seniority tended to improve performance.
- How, and how much, seniority helps C^2 depended upon which team was observed.

Although the experiment did not actively seek different group behaviors, observation suggested, and subsequent analysis confirmed, the presence of two distinct approaches to C^2. The differences between the two groups' approaches to C^2 can be seen by comparing Figures 1 and 2. Figure 1 displays a causal influence matrix for Group A, and Figure 2 for Group B. Although it is difficult to generalize about the patterns of these matrices, it is clear that they are different. Only about half of the entries in each figure have a corresponding entry in the other. These differences confounded the statistical results originally expected from the experiments, and can be seen to some extent in the effects of seniority.

FROM \ TO	C^2 Info Search			Communications				C^2 Effort			Execution			Force Effectiveness			
	RANGE	VARIETY	VIGILANCE	TOTAL MESSAGES	COM-SECONDFLT MESSAGES	OTHER MESSAGES	MESSAGE DELAY	SYSTEM SCOPE	SYSTEM QUALITY	SYSTEM CAPACITY	STRIKE SIZE	TIMELY LAUNCH	CVBG COMMANDS	FUTILE FIRING	ORANGE LOSSES	BLUE LOSSES	EXCHANGE RATIO
Scenario (Threat)									+0.07*								
Previous Scenario			-0.19*														
Previous Exchange Ratio		-0.27	-0.27*														
Clear Communications					+0.02*										+0.09		
Seniority				+0.18						-0.05*							
Hybrid C^2 Organization					+0.02*												
Significant Intelligence																	
Session																	+0.20*
Session Half	-0.05			+0.14		+0.06	-0.07	-0.07*		+0.03*							
CVBG Message Load																	
CVBG Scope																	
CVBG Quality																	
CVBG Capacity	-0.68*																
Range									-1.20	-1.44							
Variety										+1.11							
Vigilance										-0.30				+0.79*			
COMSECONDFLT Messages					+0.21#	+0.50							+2.23				
Other Messages					+0.88	+0.24#											
Message Delay									+0.85	+0.75							
System Message Load												-0.97*					
System Scope																	
System Quality							+0.36										
Strike Departure Time											+0.60						
Futile Firing																+0.63	-0.30

Figure 1. Causal Influences for Group A

KEY:

*Confidence level less than 95%

#Average node-level coefficient from incoming to outgoing message volume

		C^2 Info Search			Communications				C^2 Effort			Execution			Force Effectiveness			
FROM	TO	RANGE	VARIETY	VIGILANCE	TOTAL MESSAGES	COM-SECONDFLT MESSAGES	OTHER MESSAGES	MESSAGE DELAY	SYSTEM SCOPE	SYSTEM QUALITY	SYSTEM CAPACITY	STRIKE SIZE	TIMELY LAUNCH	CVBG COMMANDS	FUTILE FIRING	ORANGE LOSSES	BLUE LOSSES	EXCHANGE RATIO
Scenario (Threat)																-0.19		
Previous Scenario		+0.13	+0.20	+0.22														
Previous Exchange Ratio																		
Clear Communications						+0.09											+0.12*	
Seniority		+0.21			+0.38						-0.17							
Hybrid C^2 Organization																		
Significant Intelligence											+0.07							
Session																		
Session Half					+0.19			-0.06	-0.13		-0.13							
CVBG Message Load		-1.02	-0.75															
CVBG Scope		+1.57			+0.68													
CVBG Quality		+1.13*	+0.25*															
CVBG Capacity		-1.94*																
Range																		
Variety											+0.46				-0.95*			
Vigilance															+0.76*			
COMSECONDFLT Messages						+0.47#					+0.55			+1.35				
Other Messages						+0.67	+0.63#						+1.37					
Message Delay											-0.82						-2.58	
System Message Load													-0.97					
System Scope													+1.09					
System Quality																		
Strike Departure Time												+0.36*						
Futile Firing																		-0.13*

Figure 2. Causal Influences for Group B

KEY:

*Confidence level less than 95%

#Average node-level coefficient from incoming to outgoing message volume

Personnel Seniority

Both Figures 1 and 2 show seniority as tending to have a negative effect on C^2 capacity. (The capacity measure incorporates both the scope of C^2 activity and the quality of C^2 performance.) This finding is counter-intuitive, and must in any case be qualified by the following considerations:

- the effect is weak, i.e., the regression coefficients are small;
- for Group A, the hypothesis that the coefficent is zero can be rejected only at a confidence level of 88%. Normal scientific standards would require a level of .95 or better for acceptance, but the small number of relevant trials makes such a level difficult to obtain.

For Group B, it is possible to trace two indirect chains of effects through Figure 2 from seniority to C^2 capacity. However, the net effects of these chains differ in sign, and the direct coefficient (-0.17) must be taken as the best estimate of the effect of seniority.

Role Seniority

The second detectable impact of "seniority" came from role definition. Here, of course, seniority is notional rather than actual. Seniority is presumed to accompany and partly account for differences in command node authority and responsibility.

In fact, comparable personnel were used throughout the C^2 system. What differed was the command role each person assumed. What appeared to happen is that people "grew into" their experimental role. This growth produced some dramatic contrasts.

- Subordinate, or more "junior", nodes behaved as if they were at the limit of C^2 capacity. Therefore they tended to trade between C^2 quality and C^2 scope as follows:

$$C^2 \text{ quality} \underset{-.41}{\overset{-.27}{\rightleftharpoons}} C^2 \text{ scope}$$

- Conversely, superior or more "senior" nodes were so focused on C^2 planning that scope and quality reinforced each other as in:

$$C^2 \text{ quality} \underset{+.40}{\overset{+.30}{\rightleftharpoons}} C^2 \text{ scope}$$

The basic distinction was that the "junior" nodes acted on average as if C^2 capacity must be allocated between quality and scope, with one being improved only at the expense of the other. Notionally, more "senior" nodes, however, showed C^2 scope and quality to be naturally reinforcing: to attempt more improved quality, and improving quality encouraged growth of scope.

The coefficients shown above are averages of the statistically significant values for Group B. In Group A, the same pattern appeared, but none of the coefficients were significantly different from zero.

SENIORITY IN FLEET EXERCISES

Recent exercises (Battle Force In-port Training, or BFIT) conducted in the U.S. Second Fleet have used scenarios similar to the one in this experiment; and performance of the participating battle staffs has also been evaluated using measures taken from HEAT.

Some effects of varying the seniority of the the participants have been observed in these exercises. The effects are best summed up by saying that the presence of senior decisionmakers (O-6 and above) in the command center paralleled a measurably higher level of performance by the staff as a whole. Specifically, in BFIT 2-86, where the presence of senior personnel was intermittent compared to earlier exercises, several HEAT measures (notably the time taken to complete a decision cycle) were significantly worse.

Unlike the experiments, the structure of the exercises did not allow control of the level of seniority or repeated trials to establish statistical correlation. The association of the changes in performances with the participation of senior personnel is based on the judgment and comments of experts who were present. Professional observers from Tactical Training Group Atlantic (TACTRAGRULANT) feel very strongly about the effect and have repeatedly pressed the argument that performance is impacted by senior presence and involvement.

The effect described here pertains to real seniority. The effect of notional seniority, observed in this experiment, has not been isolated in the exercises.

CONCLUSIONS

The results of this investigation, which was initiated well after the experiment had been designed, are not conclusive. The small number of cases involving senior personnel (4 out of 32) probably limited the statistical significance of the findings. The fact that notional seniority was not defined as an experimental parameter limited the scope and precision of its investigation.

Predictable effects of seniority on staff behavior may have implications for the design of headquarters. On the other hand, the absence of such effects extends the validity of observations made with more junior staffs. The effects of seniority therefore remain a subject of experimental interest. Future experiments should be designed to be balanced so as to give those effects full play, and to permit as thorough an analysis of those effects as is provided for other variables. In particular, experimental participants should include a much larger proportion of senior personnel.

It would therefore be useful if future DCA sponsored experiments were located in a greater variety of testbeds and laboratories, particularly those where more senior personnel routinely participate in exercise play.

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